Effects of crystal orientation on the drift direction in Ge detectors

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The recently proposed concept of γ-ray tracking relies on the determination of the positions of individual interactions of γ rays in a Ge detector as well as their energies. These parameters are obtained by analyzing both net charge and image charge signals in a two-dimensionally segmented Ge detector, such as the 36-fold segmented GRETA prototype. The analysis is done by comparing measured and calculated signals. To determine the position with an accuracy of about 1 mm, crystal orientation effects on the charge carrier drift velocity and direction have to be taken into account. For instance, neglecting the crystal orientation effect on the magnitude of the velocity will cause an error in the radial position of up to 3 mm. In addition, the direction of the drift velocity is not the same as the direction of the electrical field, and the angle between them depends on the crystal orientation. We were able to measure this effect in our 36-fold segmented GRETA prototype detector as shown in fig.1. At the beginning of the measurement our two-dimensional collimation system was aligned to the outside edge of the B/C boundary (top part of figure) by requiring equal intensities in segment B4 and segment C4 (letters indicate the azimuthal, numbers the longitudinal position). This ensured that the drift of the charge carrier collected close to the segmentation line (here the holes) was not influenced by the crystal orientation. Adjusting the y-position to keep the intensities of the 662 keV line (from a ^{137}Cs source) equal while moving inwards allowed us to determine the origin of the charge carrier, e.g. the location of the interactions. The red circles in the figure indicate the adjustments which were required to collect the charge carrier at the B/C boundary. The lower three figures show the adjustments for the B/C, A/B, and A/F boundary in millimeters. An adjustment of up to 1 mm was needed between the outer and inner radii for the B/C and A/F boundaries. For A/B the adjustment was less than 0.1 mm. The magnitude and direction of the adjustments for the three different boundaries reflect the underlying crystal orientation.

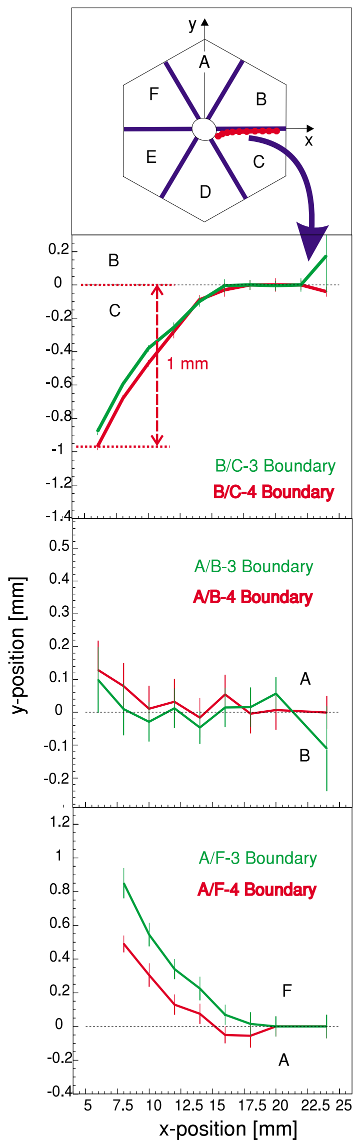

Figure 1: Collimator positions to produce equal intensities in adjacent segments representing the origin and the pathway of the charge carrier.